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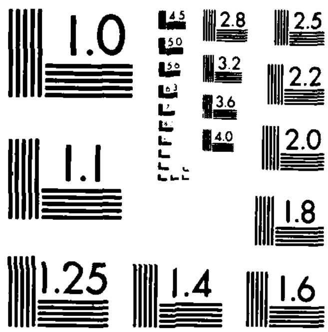

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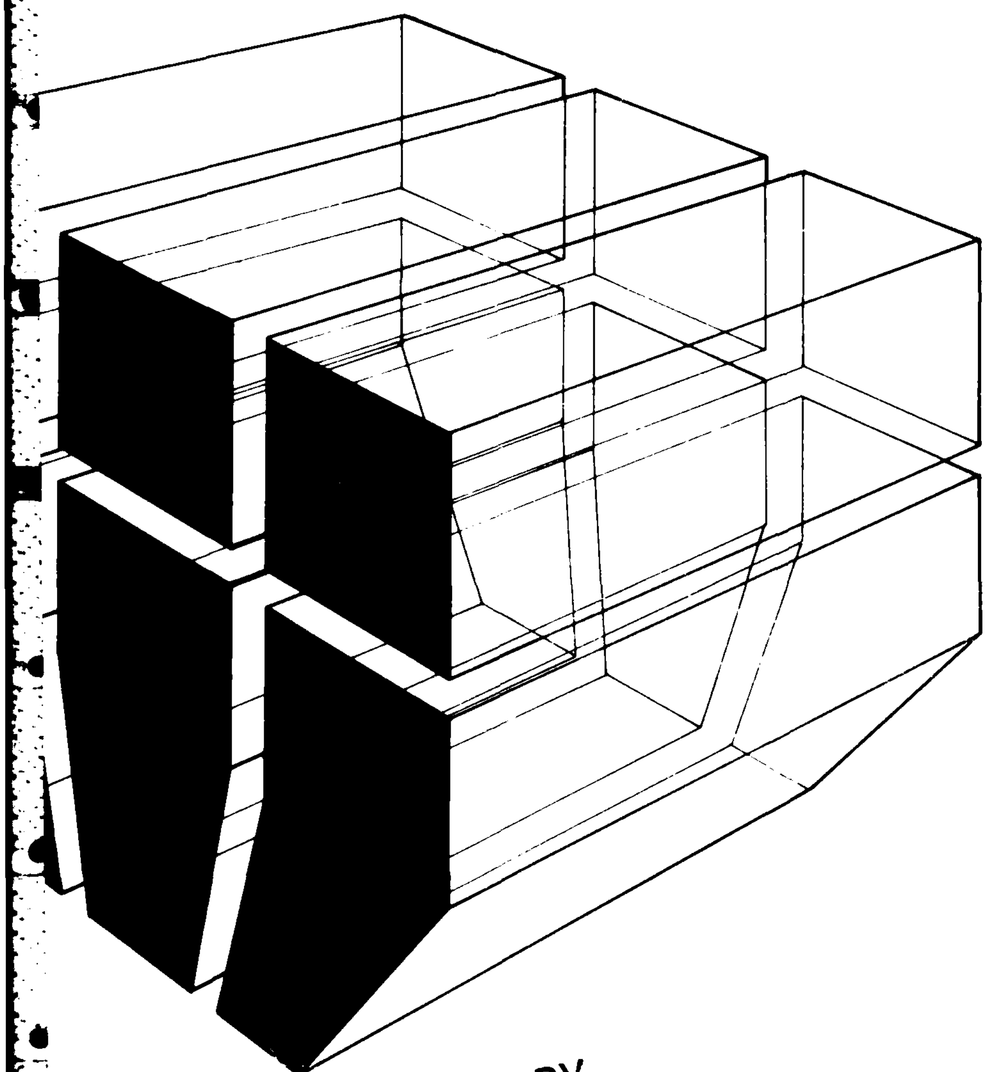
Technical Report N-146
April 1983

Water Conservation and Reuse Guidelines

WATER CONSERVATION METHODS FOR U.S. ARMY INSTALLATIONS: VOLUME I, RESIDENTIAL USAGE MANAGEMENT



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The objectives of this report were: (1) to compile information on methods of conserving water, and (2) to provide guidance that facilities engineers can use to identify practices that conserve water in residences and that are appropriate for the Army. To accomplish these objectives, the U.S. Army Construction Engineering Research Laboratory (CERL) conducted literature searches and manufacturer surveys to determine the availability, compatibility, cost, and performance of household devices that conserve water.

(Cont'd)

CERL's work indicates that the following guidelines can help conserve water:

1. Water conservation should be considered as part of the installation's energy conservation program.

2. Water conservation techniques, such as installing devices on household fixtures, are an important part of comprehensive water supply planning, and should be considered for retrofitting and for new construction projects.

3. Because many types of conservation devices are available, the facilities engineer can select proven device technology with which there is little risk of failure or public rejection. The transition from conventional fixtures to water conservation devices usually can be made without major behavior changes by residents.

These guidelines are applicable at installations inside and outside the Continental United States under both peacetime and mobilization conditions.

Volume II provides guidance on identifying practices that conserve water in irrigation.

FOREWORD

This study was performed by the Environmental Division (EN), U.S. Army Construction Engineering Research Laboratory (CERL) for the Assistant Chief of Engineers, under Project 4A762720A896, "Environmental Quality Technology"; Technical Area A, "Installation Environmental Management Strategy"; Work Unit 031, "Water Conservation and Reuse Guidelines." The applicable QCR is 6.27.20A. The OCE Technical Monitor was Walter Medding, DAEN-ECE-D. Dr. R. K. Jain is Chief of EN.

Appreciation is expressed to Sharen Kloster, Robert Fileccia, and Cynthia Watson, all of CERL, for their work supporting this project -- and especially to Joseph Matherly (CERL) for anticipating the Army's need for this type of research.

For their administrative and technical assistance, appreciation is extended to Mr. Craig Withee, formerly Sanitary Engineer, Fort Carson; Mr. David Hanke, Sanitary Engineer, Fort Lewis; Mr. Manny Ortega, formerly Sanitary Engineer, Fort Bliss; and Mr. Louis Castro, present Sanitary Engineer, Fort Bliss.

COL Louis J. Circeo is Commander and Director of CERL, and Dr. L. R. Shaffer is Technical Director.

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1 INTRODUCTION

Background

The U.S. Army uses more than 130 billion gallons of water annually and spends more than $130 million for operation and maintenance (O&M) of its water and wastewater utilities. As demands and costs increase, and limits are imposed on spending, water conservation technology becomes important for effective installation management. To provide facilities engineers with information about this technology, the Office of the Chief of Engineers asked the U.S. Army Construction Engineering Research Laboratory (CERL) to examine methods of conserving the water used in residences and for turf maintenance. These uses account for much of the water consumed at an installation; for example, irrigation for lawn and turf maintenance takes as much as half of the water used during warm months. At one installation, winter per capita usage averaged 100 gallons per day (gpd); in summer, the usage increased to nearly 400 gpd. When shortages appear imminent, the water used in residences and for irrigating lawns and turf can be cut significantly by the techniques described in this report. With this guidance and that described in Volume II for turf maintenance, the threat of shortages can be reduced, and it might not be necessary to go to the expense of finding additional water supplies. The water conservation techniques described are applicable at installations inside and outside the continental United States under both peacetime and mobilization conditions.

Objective

The overall objective of this study is to analyze water conservation at fixed Army installations. The objectives of the phase of the study documented in this report were: (1) to collect information on methods of conserving water, and (2) to provide guidance that facilities engineers can use to identify practices that conserve water in residences and that are appropriate for the Army. Volume II provides guidance on identifying practices that conserve water in irrigation. A future report will assess data collected during field surveys of water used in residences at Fort Carson.

Approach

To accomplish the objectives of this phase of the study, CERL conducted literature searches and manufacturer surveys to determine the availability, compatibility, cost, and performance of household devices that conserve water.

Mode of Technology Transfer

Information from this study may impact Technical Manual (TM) 5-660, TM 5-661, TM 5-551, TM 5-630, TM 5-830-1, TM 5-830-2, and TM 5-830-4[1].

1 Operation of Water Supply and Treatment Facilities at Fixed Army Installations, Technical Manual (TM) 5-660 (Headquarters [HQ], Department of the Army [DA], November 1952); Inspection and Preventive Maintenance Services for Water Supply Systems at Fixed Installations, TM 5-661 (HQDA, September 1945); Plumbing and Pipefitting, TM 5-551 (HQDA, July 1971); Repairs and Utilities -- Ground Maintenance and Land Management, TM 5-630 (HQDA, December 1967); Planting Design, TM 5-830-1 (HQDA, June 1976); Planting -- Planting Turf, TM 5-830-2 (HQDA, October 1961); Planting and Establishment of Trees, Shrubs, Ground Covers and Vines, TM 5-830-4 (HQDA, June 1976).

2 WATER CONSERVATION BY THE ARMY

The Importance of Conservation

The advantages of conservation have become evident as the supplies and the quality of water have declined in many areas. Where groundwater is the major or sole supply of water, it is being withdrawn faster than the recharge rates. With increased pollution of surface water and groundwater, it will become harder to maintain high quality water supplies. For many years it was thought that increasing demands could be met by increasing supplies, but extensive drought across the country has made severe water shortages a national concern. Conservation measures can be used effectively to help ease some of these shortages.

Conservation has traditionally meant saving or storing water, but today the definition has broadened to include the wise use and management of this resource. Conserving water offers many benefits: energy savings from pumping, handling, and processing; reduced loads on sewage and water treatment plants; less demand for new supplies or less time needed to plan for new supplies; adequate supplies during droughts; and economic savings to the customer. The goal of conservation is to provide the greatest use from existing supplies.

The Army's Use of Water

There are more than 100 fixed Army installations across the United States. Each post is like a small city, with a large residential section and commercial, industrial, and recreational sectors (Table 1). While the basic water uses by military installations and cities are similar, the unusual features of military posts should be recognized:

1. Because of the large number of civilian employees, the population can fluctuate greatly from day to evening.

2. Maneuvers, leave passes, and training exercises may also cause population fluctuations.

3. Army personnel must follow command orders and instructions; therefore, directives ordering water conservation can be enforced quickly.

4. Activities unique to the Army affect water and wastewater plants -- e.g., tactical vehicle washing and maintenance, and aircraft maintenance.

5. Army personnel pay a fixed amount for unlimited quantities of water. Thus, rate structures cannot encourage conservation because personnel do not directly pay for the amount of water they use. Other incentives for conservation must be found.

Table 1

Typical Activities Related to Water and Wastewater at Army Installations

Administration/Institutional	Industrial
Unclassified office space	Vehicle wash racks
Shipping and receiving facilities	Aircraft wash
Communications facilities	Steam cleaning
Command-level headquarters	Metal plating and finish
Radar installations	Autoclaves
Military training and instruction facilities	Boilers
	Metal cleaning
	Paint booth water well
Wastewater Management	Air pollution wet scrubbers
	Laboratories
Sewage treatment	Cooling towers
Industrial waste treatment	Dynamometers
Wastewater disposal	Engine test cells
	Ash handling systems
	Industrial laundries
Housing	Pesticide management area
	Photographic laboratory
Family housing	
Barracks	
Bachelor officers quarters	
Visiting officers quarters	
Commercial	
Commissary	
Post exchange	
Gas station	
Laundromats	
Restaurant/cafeterias	
Post office	
Bank	

Army Guidance

The Army now has no official regulations on water conservation devices at fixed military installations. However, many Army posts have developed their own water conservation plans for dealing with drought and reducing the water usage of all activities on post. TM 5-660 has a section on water conservation, stressing its importance and mentioning some simple ways to reduce consumption. For Civil Works projects, OCE has developed an implementation plan for water conservation.[2] But at fixed military installations, the responsibility for water conservation lies with the facility engineer and the base commander.

Command Emphasis

The facilities engineer should seek the commander's support for water conservation. The commander's emphasis on conservation will increase the effectiveness of the program by increasing its priority.

Residential Water Usage

Except for vehicle wash and irrigation, family housing is the largest consumer of water on a military installation. (Average residential water usage is shown in Table 2.) Residential water conservation contributes to savings for the entire installation. Though individual savings may seem small, the overall effect can be a significant reduction in water use. For consumer water management programs to be effective, conservation by individuals must be emphasized.

Flushing toilets and watering the lawn take the most water in an average household.[3] Variations in water use have been correlated with many factors, such as standard of living, climate, personal habits, and the number and ages of the people in a family.[4] Army residential uses are similar to those in the public sector, so the Army should realize similar benefits from water conservation programs: reduction of water consumption, savings of money and energy, reduction of loads on water and wastewater treatment plants, and education of the public about the importance of water. Examples of some benefits are in Appendix A.

The use of the conservation methods discussed in Chapter 3 should be just one element in such programs, which may also include metering and rate structure control, reuse, legislation, and behavioral changes.

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[2] Evaluation of Water Conservation for Municipal and Industrial Water Supplies -- Procedure Manual, IWR 80-1 (Institute for Water Resources, April 1980).
[3] Murray Milne, Residential Water Conservation, California Water Resources Center Report No. 35 (California Water Resources Center, March 1976).
[4] Milne, 1976.

Table 2

Distribution of Residential Water Use

Indoor Water Consumption	Percent	Typical Usage, gpcd
Toilets	45	32
Bathing and Personal	30	21
Laundry and Dishes	20	14
Drinking and Cooking	5	3
		70
Outdoor Water Consumption		
Irrigation	Variable	--
Swimming Pools	Variable	--
Car Washing	Variable	--
		70 gal total assumed for outdoor uses

Note: gpcd = gallons per capita per day.

3 METHODS FOR CONSERVING WATER IN RESIDENCES

Leak Detection

Water conservation for individual residences should first focus on leaks and waste resulting from poor water-use habits: leaving the water running while brushing teeth, shaving, and preparing meals; not using the proper settings on washing machines; placing sprinklers improperly; and not replacing or repairing leaky fixtures. Tips for conserving water are published by many sources: U.S. Government agencies, local and State governments, and water utilities.[5]

Residential water leaks can account for 5 to 10 percent of the total water consumption.[6] Most of these leaks can be fixed with simple maintenance procedures, such as replacement of worn washers (TM 5-551). Even small leaks of 80 drips per minute can waste 2500 gal a year. Leaks can also be a nuisance, causing noises and water marks. Public education and prompt service by the plumbing maintenance shop can encourage personnel to report leaks.

Programs which check distribution lines for leaks in equipment and fixtures should be instituted.[7] Meters are useful in detecting major water losses within the household. For example, the meter can be checked before residents go to sleep and again in the morning. Differences in the meter readings indicate water loss in the system. The high initial cost of installation is the main problem with meters. In the long run, however, the meter can provide information valuable enough to offset this short-term disadvantage. Leaks in mains can be detected by three methods: ultrasound, pressure differential, and meter reading.

Pressure Reduction

The pressure of the mains and laterals of the water distribution system may vary throughout the post. The pressure may be especially high (>80 psi) in certain areas for many reasons, such as a steep gradient. Proper placement of pressure reduction valves can conserve water in two ways. First, less pressure insures that less water is delivered to the consumer; therefore, less water is wasted. Second, because all water mains leak, reduced pressure

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[5] See, for example, "44 Ways To Be Water Wise" (Denver Water Department, n.d.); Before the Well Runs Dry: A Seven-Step Procedure for Designing a Local Water Conservation Plan, Vol II (New England River Basins Commission, July 1980); "Leak Survey Pays Off," Water & Sewage Works (November 1974); Richard J. Rago and Donald E. Crum, "Leak Detection Program Trims Water Waste," Public Works (June 1976); Paul M. Heim, "Conducting a Leak Detection Search," Journal of the American Water Works Association (February 1979); Municipal Officials Guide to Water Conservation (New England Interstate Water Pollution Control Commission, January 1980); Murray Milne, Residential Water Conservation, California Water Resources Center Report No. 35 (California Water Resources Center, March 1976).

[6] Milne, 1976.

[7] "Save H_2O With Leak Detection," Facilities Engineering Support Agency (FESA) Bricks, Vol 3, No. 1 (January 1981).

insures that less water is lost through leaks. The valves are inexpensive, compared with potential savings, and do not require frequent maintenance. Note that when pressure reduction is considered, minimum pressure standards must be complied with.

Conservation Devices

The devices most commonly used to conserve water are shallow trap toilets, dual flush toilets, toilet inserts, flow restrictors, aerators, low-flow shower heads, hose attachments, and pressure-reducing valves. Most of these are designed to operate like conventional equipment, thus requiring few changes in residents' habits. Many of the devices may even be more convenient than the originals.

Table 3 analyzes water conservation methods. Appendix B is a list of some of the companies producing conservation devices. Table 4 compares the installation and use of four specific devices. Table 5 lists common conservation equipment, gives its cost, and describes consumers' attitudes toward it. Table 6 lists devices for special situations.

Toilets

There are four types of toilets: two-piece with tank detached, two-piece with tank (close coupled), one-piece with tank, and one-piece tankless. The two-piece is an older design. The tank is raised high above the bowl, which gives high water velocity and requires less water per flush. The most common toilet is the two-piece close coupled. Its tank is connected directly to the bowl and generally requires 5 to 8 gal per flush. The one-piece has no tank but is connected directly to the water line. This system generally is not used in individual residences because it requires high water flow rates, which usually cannot be met by standard residential water lines.

Stopping Leaks. If the toilet is noisy or runs on after it is flushed, water is probably leaking. Some parts of the toilet mechanism may simply need to be adjusted (Figure 1). Leaks usually can be found if the float and the seat of the valve are checked. Take off the float and shake it; if water can be heard, replace the float. Special floats are now made which rise more efficiently and do not become waterlogged. The signal float is efficient and makes a gurgling noise if there is a leak.

If the toilet still makes noise after these steps have been taken, the flush ball probably needs to be adjusted so it will seat properly. If a new flush ball is needed, it can be replaced with a "flapper assembly." This does not have a guide arm and guide wire, and therefore does not have to be adjusted as a flush ball does.

Silent leaks, which overflow into the bowl, can waste hundreds of gallons of water a day -- a major loss. When checking for these leaks, first make sure that the float is adjusted so that the water does not run into the overflow tube. Also see whether the ballcock is leaking directly into the overflow tube. (Some new types of ballcocks can be adjusted to lower water levels in the tank.) To detect a silent leak, remove the tank cover and add some food coloring to the water. (Commercial dye capsules are also available.)

Table 3

Analysis of Water Conservation Methods*

Conservation Method	Comments
Leak detection and repair	Cannot rely on many users to do leak detection in homes or businesses.
Water-saving fixtures	Simple fixtures that require little change in user habits and are convenient to install would be appropriate; otherwise may be unacceptable.
Reuse-recycle	Generally too expensive, difficult to operate, socially/aesthetically difficult to accept for full implementation.
User habit changes	May work temporarily; cannot be relied on for long-term.

* Adapted from Before the Well Runs Dry -- a Seven-Step Procedure for Designing a Local Water Conservation Plan, Vol II (New England River Basin Commission, October 1980).

Table 4

Device Installation and Usage

Device	Cost	Comments
Faucet aerator	$2.00	Easy to install, but installation's Water Department should do some to insure full installation. Well accepted — no maintenance problems.
Plastic bottles for toilet tank displacement	$.50	To insure full installation, Water Department should assume some installation duties. Also, bottles very reusable and can fit in most models.
Dams for toilet tank displacement	$2.50 per dam	To insure proper installation, Water Department should install. Dams may not fit all toilet models. Dams must be periodically adjusted.
Shower flow restrictors	$.25 per restrictor	To insure proper installation, Water Department should install some. May have problems with customer acceptance.

Table 5

Conservation Devices*

Fixtures	Short-(S) or Long-Term(L) Need	Cost: Capital	Cost: Compared to Conventional Fixtures**	Comments
Indoor, For Average Demand Problems				
Shallow trap toilet	L	$75	=	Very well accepted by users.
Dual flush toilet	L	$85	=	Minor change in use pattern required.
Toilet tank inserts	S,L	$.90-4.00	N/A	Retrofit to conventional fixtures.
Shower flow restrictors	S,L	$.75-25.00	=	Some retrofit to conventional fixtures.
Faucet aerators	L	$1-5	=	Well-accepted by consumers.
Hot water pipe insulation	L	$.50/ft.	N/A	Saves up to 8 gal per capita per day.
Vacuum flush toilet	L	Expensive	Higher	Mixed acceptance by consumers.
Pressurized flush toilet	L	$360	Higher	Requires electricity.
Electrically controlled plumbing	L	New installation not much more than conventional plumbing	75%	Reductions not documented. Probably cost-effective for new developments only.
Hot water recirculation	L	Hundreds of dollars	Eliminates waste while waiting for hot water	Cost-effective for new developments only.
Automatic dishwasher	L	$175-350	Could save, if properly used	Widely used.
Automatic clothes washers--suds saver	L	N/A	$15-20 more than conventional	Not now generally used.
Functionally designed sinks/tubs	L	Not significantly more than conventional	Potential savings	Reduces volume in tub/sink to minimum necessary. Limits aesthetics of fixtures.

* Adapted from Before the Well Runs Dry -- A Handbook for Designing a Local Water Conservation Plan (New England River Basin Commission, October 1980).
** Not applicable (N/A); equivalent (=).

Table 5 (Cont'd)

Fixtures	Short-(S) or Long-Term(L) Need	Cost: Capital	Cost: Compared to Conventional Fixtures**	Comments
Bidets	L	$70	Potential savings	Not culturally acceptable in America.
Bottled water	S	$.50/gal	Users generally do not waste	Usually cooking and drinking only.
Solar stills	L	$500	N/A	Mostly for use where water is brackish.
Chilled water dispenser	N/A	$200 more than conventional luxury model refrigerator	Saves by eliminating running water	"Luxury" item.
Thermostatically controlled mixing valve	S,L	$60	Reduces water waste while waiting for correct temperature	"Luxury" item.
Pressure balancing mixing valve	N/A	$45	Potential savings	Mostly for showers (avoid thermal shock). "Luxury" item.
Leak signaling ballcock for toilet	L	$6-10	Potential savings is high	Loud noise when there is a leak.
Outdoor, For Peak Demand Problems				
Drip irrigation systems	L	$7-30	*	For gardens, trees, shrubs only.
Time-controlled sprinkler	L	$70 and up	Higher	Needs electricity.
Moisture indicators	S	$.05-25.00	*	Mixed acceptance by consumers.
Hose attachments	L	$1-40	*	Well accepted by consumers.
Swimming pool covers	L	$220-4800	N/A	Mixed acceptance by consumers.
Tensiometers	L	$15-30	N/A	Mixed acceptance by consumers.
Tank flushing valve for toilet	L	Insignificant	Potential savings	More efficient flapper type.
Variable flush	S,L	$5 (Retrofit)	50%	User depresses valve for as long as necessary. Not as acceptable as dual flush.

Table 6

Special Systems*

Domestic Indoor Fixtures	Cost	Water Reduction, Compared to Conventional Use	Comments
Chemical toilets: self-contained	$100	100%	Mostly for recreation areas/vehicles.
Fresh water flushing: self-contained	$60	99%	Mostly for recreation areas/vehicles.
Fresh water recirculating: self-contained	$250	98%	Mostly for recreation areas/vehicles.
Waste water recycling toilet	$1400-1650 (capital) $100-300 (installation)	45%	Mostly for remote areas.
Pressurized tank toilet	$40 (retrofit costs to conventional unit)	50-60%	35-120 psi needed in supply line. Possible for small development.
Controlled volume flush toilet	--	--	Mostly for marine use; not adaptable to home.
Oil flush toilet	$2500 (not installed)	99%	Suitable for areas with waste water disposal problems.
Composter toilet	$950 (not installed or delivered)	100%	Suitable for areas with waste water disposal problems.
Packaging toilet	--	100%	Needs electricity. Difficult to dispose of waste. Use in remote areas.
Incinerator toilet	$395 (capital) $75 (installation)	100%	Needs power, regular maintenance for incinerator. Use in remote areas.
Freeze toilet	$320 (not installed)	100%	Difficult to dispose of wastes; needs power. Use in remote areas.
Air-assisted shower head	$275	83-95%	Needs power. Too expensive for wide-scale use.
Self-closing mixing valves	Same as conventional (knee-or foot-operated are $75-120 or more)	Potential savings more in public lavatories	Most suitable for use in public lavatories.
Instant hot water	$100 (not installed)	--	--

* Adapted from Before the Well Runs Dry -- A Handbook for Designing a Local Water Conservation Plan (New England River Basin Commission, October 1980).

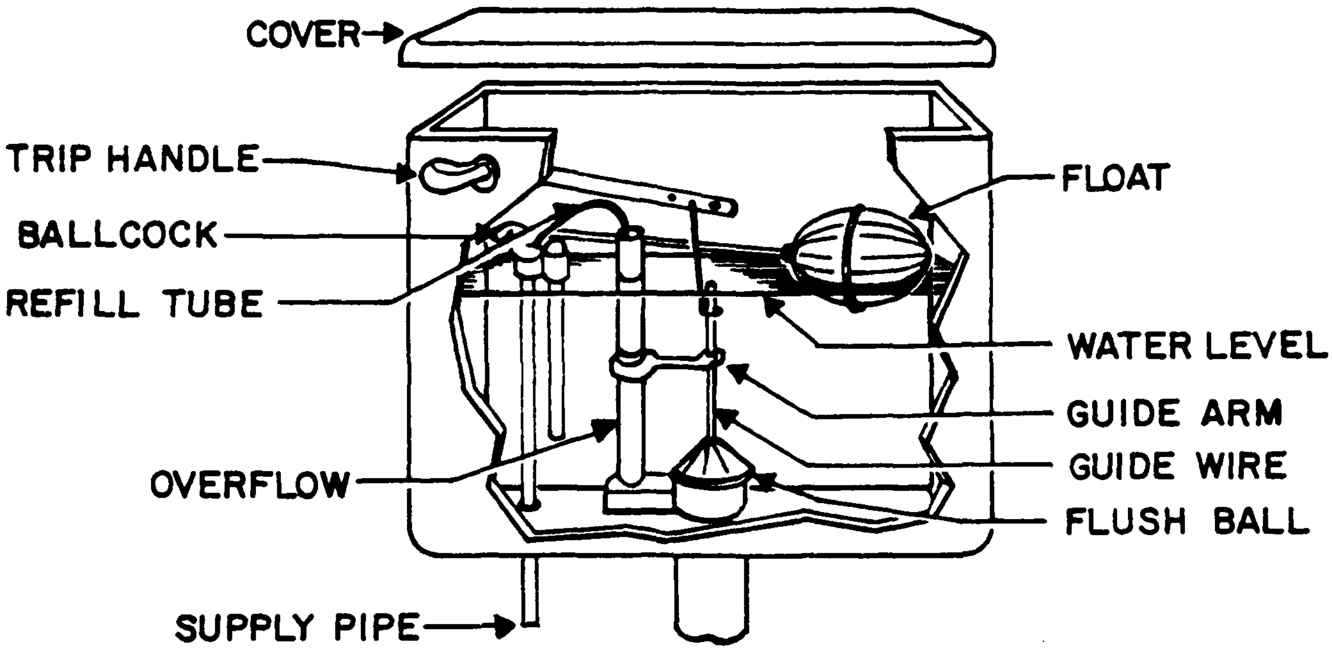

Figure 1. Standard toilet.

Then see if the dye leaks into the bowl. To check for slow leaks, let the toilet stand for several hours. If the dye goes into the bowl, the flush ball should be replaced. When this is done, also repair or replace the valve seat if it is scarred or cut.

Toilet Inserts. One of the simplest ways to reduce water use is to put weighted plastic bottles in the tank (Figure 2). The cubic area of the object displaces that amount of water; thus, less water is used. Plastic bags which hang in the tank work the same way as the plastic bottles (Figure 2). The problem with bottles and bags is that they may decrease flushing efficiency. Do not use bricks, which can fall and crack the tank; in addition, they eventually crumble and can clog the openings in the bowl. Both bottles and bags must be kept clear of the toilet mechanism to allow proper operation. In some cases, the bottles must be laid lengthwise, depending on how the tank empties. Then they are not effective -- especially if the tank has a raised valve and does not empty completely. Bottles and bags are most useful with larger toilet tanks, where there is room for them and the loss of head does not severely affect flushing efficiency.

A bracket which lowers the float can be useful for smaller toilet tanks (Figure 3). It is semi-adjustable and easy to install. This device also lowers the head into the toilet tank, so flushing may be less efficient.

Many companies make toilet dams, which conserve water by damming the bottom portion of the tank, making the effective tank capacity smaller (Figure 4). This system is better than the bottles because it retains the same head

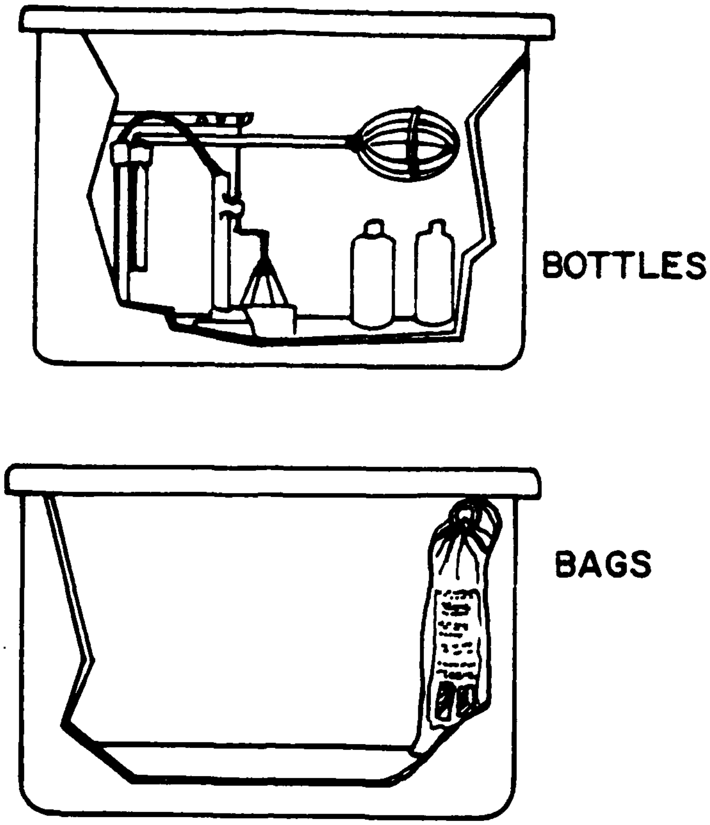

Figure 2. Bottles and bags.

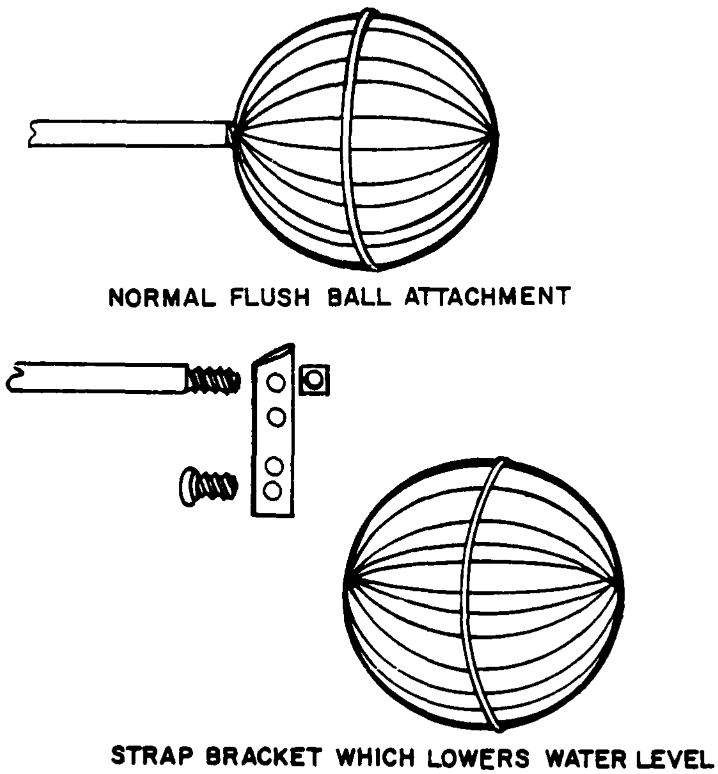

Figure 3. Bracket.

velocity. The dams are also very easy to install and relatively cheap. Manufacturers claim that the devices reduce water use 20 to 40 percent and pay for themselves in a few months. Possible problems are poor compatibility with the tank and loss of elasticity, which causes leaks and makes replacement necessary. Plastic dams tend to lose their elasticity more quickly than rubber ones.

The toilet enclosure is a more sophisticated version of the toilet dam. It encircles the valve and conserves water the same way the dam does. The enclosure surrounds the valve on three sides and then is secured with rods against the tank. This system is advantageous because it offers a better, longer-lasting seal.

Weights and Valve Raisers. Weights which attach to the flush valve allow the user to control the amount of water entering the bowl. This variable cycle is controlled by the length of time the trip handle is held down. This system can save water but may be inconvenient because the cycle is not automatic.

A valve raiser can help reduce water usage by not allowing part of the tank water to drain. This system maintains most of the effective head. To save water, the valve raiser must be adjusted to completely flush with each use.

Shallow Trap Toilets. If a new toilet is needed, many companies offer a low-flush model. It has a smaller tank than a conventional toilet, and the trapway is designed to start the siphon jet action earlier. Shallow trap toilets use 3 to 3-1/2 gal of water per flush instead of the standard toilet's 5 to 8 gal.

Two-Cycle Toilets. Less conventional toilets are also available. The two-cycle toilet has separate cycles for liquid and solid wastes (Figure 5). This system attempts to provide an efficient flush using as little water as possible. The solid waste cycle uses 2.5 gal and the liquid waste flush uses even less. The two-cycle mechanism replaces the old parts of the toilet. Though the idea is straightforward, the mechanism is difficult to install and is not adjustable. The initial investment is higher, but two-cycle toilets potentially can save more water than toilet dams.

Special Systems. Some designs do not have water as the transport medium. The oil-vacuum system uses oil; the waste is separated, and the oil is filtered and recycled. The waste is then collected, stored, and periodically dumped at a permanent site. Other innovative technology includes vacuum, incinerator, composting, and freeze toilets (Table 6). These methods are not used often because only special applications make them advantageous, and the initial investment is high.[8]

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[8] Water Conservation Devices -- Residential Water Conservation, Water Research Capsule Report (Office of Water Research and Technology, U.S. Department of the Interior, 1977).

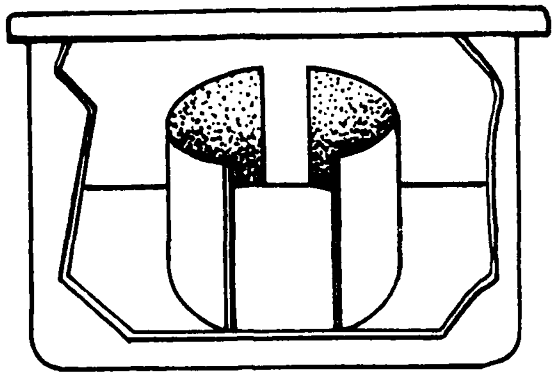

Figure 4. Toilet dams.

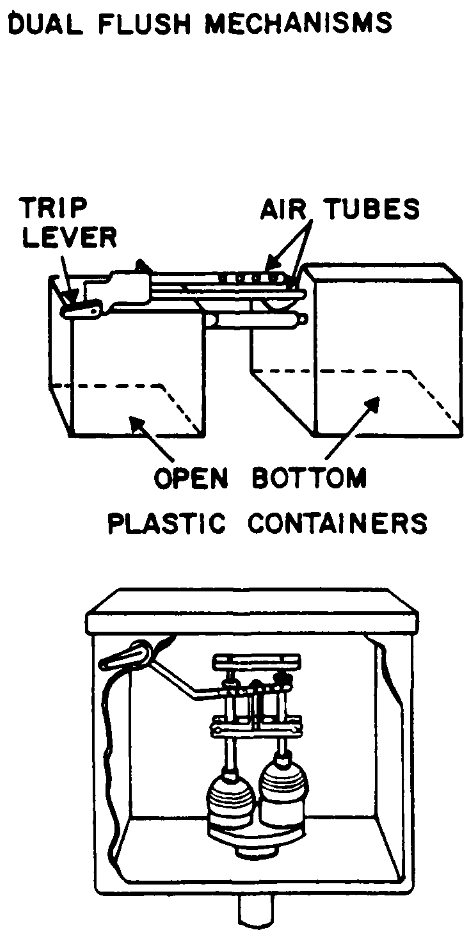

Figure 5. Two-cycle toilet.

Showers

Taking showers instead of baths can be an effective way to save water. Filling a bathtub can use more than 50 gal of water, but a 5-minute shower, with a low-flow showerhead, can take as little as 12.5 gal.

Low-Flow Showerheads. Low-flow showerheads can help cut water use without radical changes in washing habits. There are many types to choose from, so the facilities engineer can select models compatible with specific building types. Most of the devices look like conventional showerheads and usually have an adjustable flow (Figure 6). The aerating type -- which mixes air and water -- usually has a smaller spray pattern and is not adjustable. Some of the models have a shut-off valve which one can close while lathering up. This feature can provide a significant savings of water and energy. The costs of the showerheads vary widely, depending on the features and the types of materials used. To avoid weak spray patterns, the showerheads should be chosen carefully to insure that they are compatible with the plumbing.

Flow Restrictors. The cheapest way to decrease the flow is to use a flow restrictor. There are two models and two types of restrictors. The internal model is usually a plastic or metal disk which fits between the supply pipe and the showerhead (Figure 7). The external model is a threaded device which screws between the supply pipe and the showerhead (Figure 7). The two types are flow restrictors and flow regulators. The flow restrictor has a fixed opening and allows a specific flow at a specific pressure. The flow regulator compensates for different pressures and closes under increased pressure (Figure 8). This system can save more water than the flow restrictor because it is more flexible under varying conditions.

The major problem with both types of restrictors is that the spray pattern may be weak because of the reduced pressure. The systems are advantageous because of their low cost. Some companies make combination restrictors and shut-off valves which can increase water and energy savings.

Aerators

Aerators add air to water; they are installed on faucets to decrease water usage and splashing. Aerators can save 50 percent of the water run at a faucet. The laminar flow unit is useful for objects that are to be rinsed. It produces a stream of water that clings to the objects and allows more efficient rinsing, thus saving water.

Mixing Valves

The thermostatic mixing valve is a device which self-adjusts to maintain the proper temperature after the water temperature is set. The mechanism corrects for changes in temperature in the hot and cold water lines within a range of pressure changes. As the line temperature varies, this valve maintains the proper temperature with a bi-metal spring which moves to adjust the hot and cold water lines (Figure 9).

The pressure-balancing mixing valve can be useful for showers. It maintains constant water pressure by compensating for changes in line pressure (Figure 10). The valve is a mechanical device which slides back and forth as

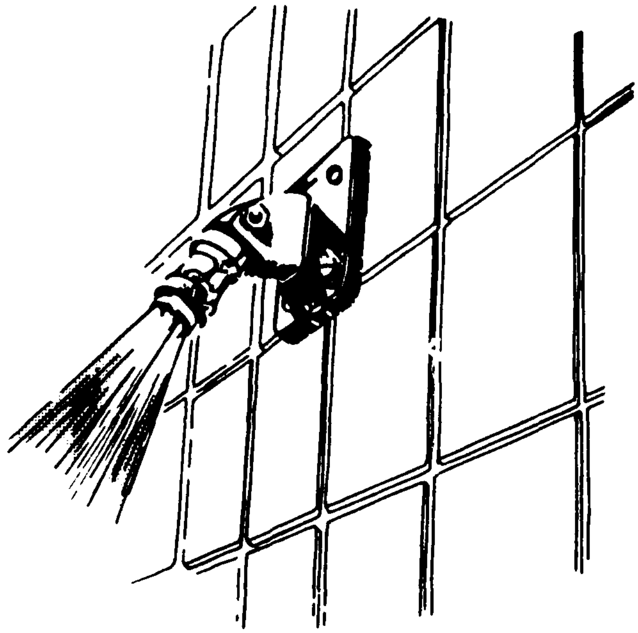

Figure 6. Low-flow showerhead.

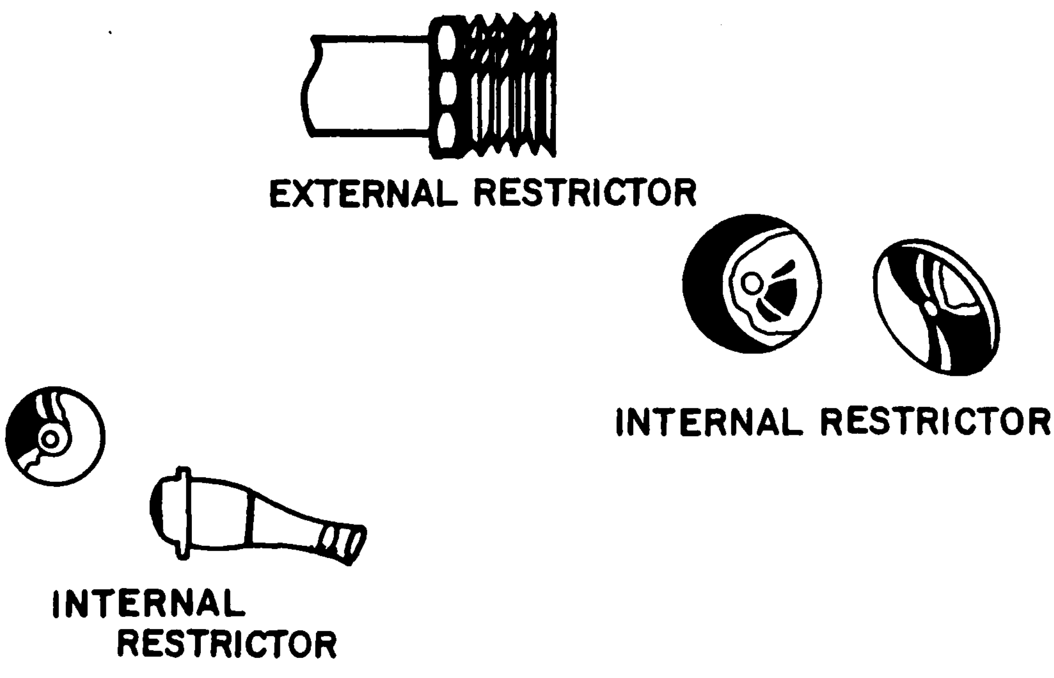

Figure 7. Flow restrictors.

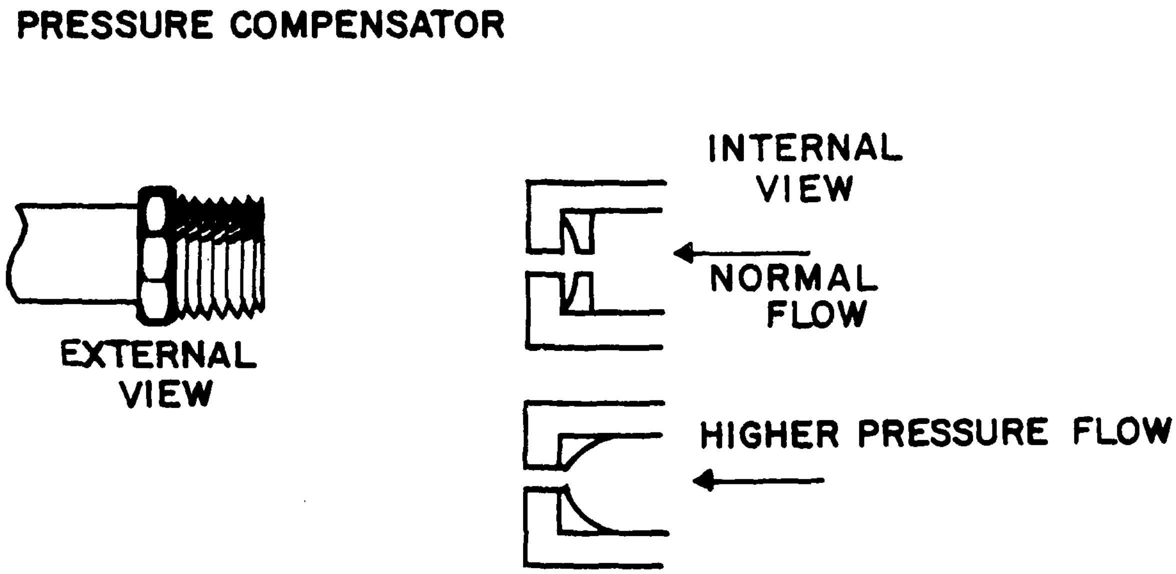

Figure 8. Flow regulator.

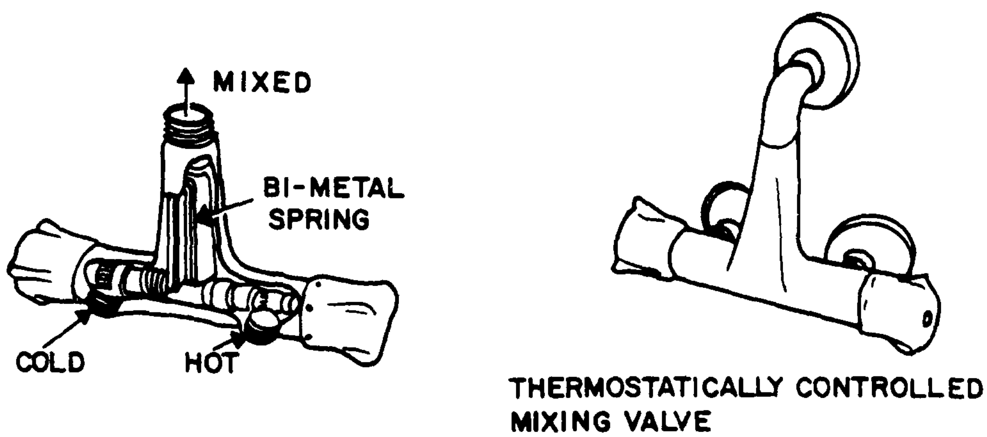

Figure 9. Thermostatic mixing valve.

the pressure changes. But unlike the thermostatic mixing valve, it does not compensate for fluctuation in the water line temperature.

Appliances

Water can be saved if residents use the special features now available on some household appliances. For example, a clothes washer might have variable water levels and a suds-saving cycle which reuses washwater, thus saving hot water and detergent. The average water use of a typical machine is 20 gal for the wash, 4 gal for a spray rinse, and 20 gal for a deep rinse. The suds-saver can cut water use by 20 percent. The savings from use of the adjustable level controls vary but can be significant.[9]

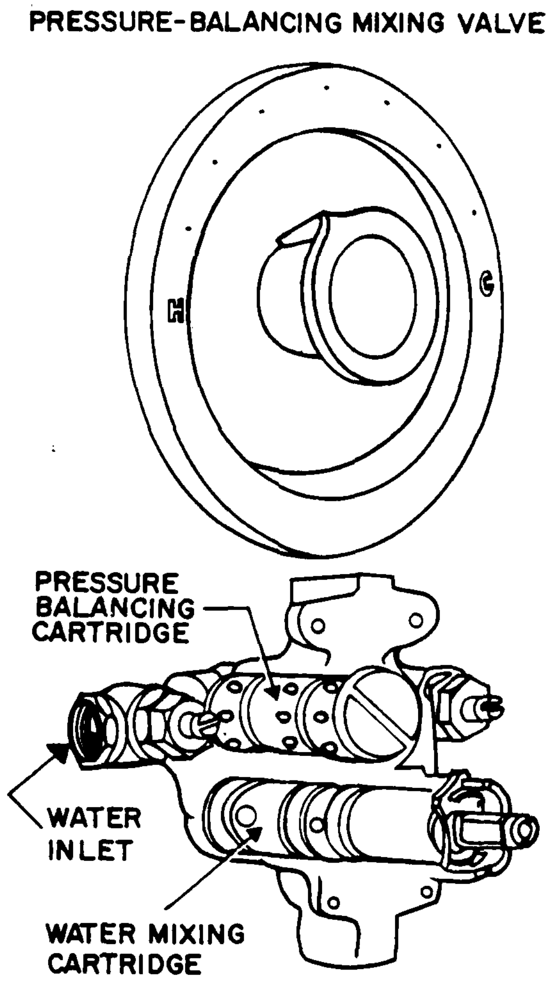

Figure 10. Pressure-balancing mixing valve.

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[9] For water usage of some washing machines, see "Washing Machines," Consumer Reports, Vol 44, No. 11 (November 1979), p 652.

The dishwasher uses about 13 to 16 gal of water for a 60-minute cycle. Additional water is required for rinsing dishes before automatic washing and for pots if they are hand-washed. Newer models allow residents to vary the amount of water used, depending on the size of the load.

Hot Water Usage

Activities and appliances which use hot water can conserve not only the water, but also the energy used to heat it. (In a laundry, 67 percent of the primary energy is for hot water.[10]) These savings are very important because energy costs much more than water. Information on energy conservation which helps conserve water should be included in an installation's water conservation program.

Water Conservation in Public Buildings

Many techniques can save water not only in family housing, but also in public buildings such as gyms, offices, and banks. Automatic shutoff valves can be used on urinals and drinking fountains. Some unconventional equipment is being used — e.g., special-media (biological) toilets, air-assisted showers, and chemical toilets like those on campers and boats. Recycle-reuse schemes also are unconventional systems which can save large amounts of water. Although public opinion is against direct reuse for consumption, this water can be useful in other areas.[11] For example, CERL's field investigations have revealed that some Army posts use recycled water for irrigation, the industrial laundry, the car and tactical vehicle wash, recreational lakes, and the industrialized photographic lab.[12]

Device Evaluation and Selection

Each post must develop its own criteria for choosing device technology. Equipment, amount of water used, and attitudes toward conservation vary from installation to installation. Therefore, only general principles for selecting and evaluating conservation devices are discussed here.

Because many devices for saving water are available, obtaining the most effective equipment can be difficult. The facilities engineer should consider cost, budget, type of device, type of existing system, conservation goals, and residents' preferences. (The references in this report cite literature which may be helpful in making decisions.) The major concern is choosing components that are compatible with residential systems.

Information about the devices should be available from local dealers, manufacturers (Appendix B), or the General Services Administration. In

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[10] W. P. Levins, Energy and the Laundry Process (Oak Ridge National Laboratory, April 1981).

[11] William H. Bruvold and James Cook, "Reclaiming and Reusing Wastewater," Water/Engineering and Management (April 1981).

[12] J. E. Matherly, M. J. Staub, L. J. Benson, and R. J. Fileccia, Water Usage Profile -- Fort Carson, Colorado, Interim Report N-34/ADA053227 (U.S. Army Construction Engineering Research Laboratory, 1978).

addition, installations can perform tests to find devices compatible with plumbing and to assess users' reactions to the fixtures.

The relative cost of various devices should be calculated before equipment is chosen. The rate of return on the initial investment may be figured in many ways. The payback period is the easiest to use; this is the number of years required to return the original investment. The method's weakness is that it ignores both returns beyond the payback period and the effects of time on the value of money. The net present value (NPV) method takes the present value of future cash flows, discounted at the appropriate cost of capital, minus the cost of the investment. The project should be accepted if the NPV is positive, and rejected if the NPV is negative. If two projects are mutually exclusive, the one with the greater NPV should be chosen.[13] The internal rate of return method uses the discount rate to equate the present value of future cash flows to the initial cost of the project.

The facilities engineer must also consider whether residents will accept various devices. An education program could explain the purpose and importance of conservation technology.[14] To help keep residents informed, the facilities engineer could use water bill inserts, pamphlets, handbooks and brochures, media advertisements, posters and displays, buttons and bumper stickers, fliers in the mail, information centers, telephone hot lines, school programs, speakers bureaus, film and slide shows, contests, billboards, newsletters, direct customer service, magazine articles, fairs, press releases, and test programs for water saving fixtures.

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[13]Eugene F. Brigham, Financial Management Theory Practice (The Dryden Press, 1979).

[14]Arthur P. Brigham, "A Public Education Campaign to Conserve Water," Journal of the American Water Works Association, Vol 68, No. 12 (December 1976), pp 665-668.

4 CONCLUSION

CERL's investigation of residential usage patterns at Army installations revealed many opportunities for installations to save water with efficient technologies and operating procedures. Most of the water conservation techniques identified would be equally applicable at installations inside and outside the continental United States under peacetime and mobilization conditions. CERL's work indicates that the following guidelines can help save water:

1. Water conservation should be considered as part of the installation's energy conservation program.

2. Water conservation techniques, such as installing devices on household fixtures, are an important part of comprehensive water supply planning.

3. Because many types of conservation devices are available, the facilities engineer can select proven device technology with which there is little risk of failure or public rejection. The transition from conventional fixtures in residence quarters to water conservation devices usually can be made without major behavior changes by occupants.

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APPENDIX A:

CASE HISTORIES

The following examples from CERL's field surveys indicate the benefits of water conservation programs in civilian communities:

1. California Department of Water Resources.

   a. San Diego

      Water conserved: 9.77×10^8 gal/year

      Cost of water: $300,000/year

      Energy savings: $860,000/year.

   b. Santa Cruz

      Water conserved: 3.13×10^8 gal/year

      Cost of water: $96,000/year

      Energy savings: $240,000/year.

   c. El Segundo

      Water conserved: 4.07×10^6 gal/year

      Cost of Water: $1250/year

      Energy saving: $2600/year.

2. Washington Suburban Sanitary Commission.

   Water conserved: 5.4 mgd. Five percent reduction in total household usage.

3. Madison, WI, saved $750,000 by not having to drill new wells.

4. Elmhurst, IL, saved $400,000 by not drilling new wells.

5. Boston Water and Sewer Commission has reduced average usage from 150 to 134 mgd.

APPENDIX B:

LIST OF MANUFACTURERS

Aerators

Conservation Associates, Inc.
P.O. Box 4717
Newark, DE 19711

Crest/Good Manufacturing Company, Inc.
325 Underhill Boulevard
Syosset, L.I., NY 11791

Ecology Products Plus, Inc.
P.O. Box 1517
North Wales, PA 19454

G&E Products, Inc.
2082 South Grand Avenue
Santa Ana, CA 92705

Key Marketing Corp.
21241 Ventura Blvd, Suite 266
Woodland Hills, CA 91364

Lynnwood Distributing Co., Inc.
140 Greenwood Ave, P.O. Drawer T
Midland Park, New Jersey 07432

Melard Mfg. Corp.
153 Linden St.
Passaic, NJ 07055

Metropolitan Watersaving Co., Inc.
5130 MacArthur Blvd. N.W./Suite 106
Washington, DC 20016

Ny-Del Corporation
740 E. Alosta Ave., P.O. Box 155
Glendora, CA 91740

Omni Products, Inc.
55666-B Yucca Trail
Yucca Valley, CA 92284

Savway Co., Inc.
930 Clarkson Ave.
Brooklyn, NY 11203

Speakman Company
P.O. Box 191
Wilmington, DE 19899

Walker, Crosweller & Co. Ltd.
140 Greenwood Ave.
Midland Park, NJ 07432

Water Saver, Inc.
P.O. Box 401
Frankfort, KY 40602

Wrightway Mfg. Co.
1050 Central Avenue
Park Forest South, IL 60466

Flow Restrictors

American Standard Aquamizer
American Standard Inc.
P.O. Box 2063
New Brunswick, NJ 08903

Business Marketing System
5936-B Don Way
Carmichael, CA 95608
(916) 485-7213

Crest/Good Manufacturing Company, Inc.
325 Underhill Boulevard
Syosset L.I, NY 11791

Eaton Corporation
Controls Division
Plumbing & Heating Products
191 E. North Avenue
Carol Stream, IL 60187

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P.O. Box 1517
North Wales, PA 19454

G&E Products, Inc.
2082 South Grand Ave.
Santa Ana, CA 92705

Kohler Company
Kohler, WI 53044
(414) 457-4441

Melard Mfg. Corp.
153 Linden Street
Passaic, NJ 07055

Mini-Dam Watersaver Corp.
640 S. Pickett Street
Alexandria, VA 22304

Moody Consumer Products
P.O. Box 15486/2201 S. Standard
Santa Ana, CA 92705

Noland Co.
2770 Warwick Blvd
Newport News, VA 23607

Ny-Del Corp.
740 E. Alosta Ave.
Glendora, CA 91740

Omni Products, Inc.
55666-B Yucca Trail
Yucca Valley, CA 92284

Savway Co., Inc.
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Brooklyn, NY 11203

Speakman Company
P.O. Box 191
Wilmington, DE 19899

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Box 18203-MC
Houston, TX 77023
(713) 371-9282

Water Guard Division
Enden Enterprises
P.O. Box 370
Arroyo Grande, CA 93420

Water Saver, Inc.
P.O. Box 401
Frankfort, KY 40602

Western Water Conservation, Inc.
10880 Wilshire Blvd., Suite 1600
Los Angeles CA 90024
(213) 879-5252

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Philadelphia, PA 19129

Wrightway Mfg. Co.
1050 Central Avenue
Park Forest South, IL 60466

Low-Flow Showerheads

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New Brunswick, NJ 08903

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Braintree, MA 02184

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5 Olsen Avenue
Edison, NJ 08817

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Newark, DE 19711

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Control Products
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Carol Stream, IL 60187

Ecology Products Plus, Inc.
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North Wales, PA 19454

G&E Products, Inc.
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Santa Ana, CA 92705

Key Marketing Corp "Nova Lowflow"
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Woodland Hills, CA 91364

Lynnwood Distributing Co., Inc.
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Passaic, NJ 07055

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Washington, D.C. 20016

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Yucca Valley, CA 92284

Savway Co., Inc.
930 Clarkson Ave.
Brooklyn, NY 11203

Southwest Supply, Inc.
6360 Carpenter Road
Lucy, WA 98503

Speakman Company
P.O. Box 191
Wilmington, DE 19899

Water Saver, Inc.
P.O. Box 401 West Main St.
Frankfort, KY 40602

Wrightway Mfg. Co.
1050 Central Avenue
Park Forest South, IL 60466

Mixing Valves

Lynwood Distribution Co., Inc.
P.O. Drawer T, Greenwood Avenue,
Midland Park, NJ 07432
(201) 447-1200

Shut-Off Values

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7500 Linder Avenue, Box 1022
Skokie, IL 60077

Savway Co., Inc.
930 Clarkson Ave.
Brooklyn, NY 11203

Speakman Company
P.O. Box 191
Wilmington, DE 19899

Toilet Inserts

Baron Manufacturing Co.
"Water Saver 105"
14439 N. 73rd St.
Scottsdale, AZ 85260

Business Marketing Systems
"Water Saver WS100"
5936-B Don Way
Carmichael, CA 95608

Chicago Specialty Manufacturing Company
7500 Linder Avenue Box 1022
Skokie, IL 60077

Crest Manufacturing Company
"Water Skimp -R"
325 Underhill Blvd.
Syosset, L.I., NY 11791

Ecology Products Plus, Inc.
"Moby Dike"
P.O. Box 1517
North Wales, PA 19454

G&E Products, Inc.
2082 South Grand Avenue
Santa Ana, CA 92705

Key Marketing Corp.
"Mini-flusher MF544"
21241 Ventura Blvd.
Woodland Hills, CA 91364

Metropolitan Watersaving Co., Inc.
"Little John"
5130 MacArthur Blvd. N.W./Suite 106
Washington, D.C. 20016

Ny-Del Corp. "Saveit Watersaver SA 720"
P.O. Box 155
Glendora, CA 91740

Savway Co. Inc. "Little John"
930 Clarkson Ave.
Brooklyn, NY 11203

Walker, Crosweller & Co. Ltd.
140 Greenwood Avenue
Midland Park, NJ 07432

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American Standard "Cadet" 2.5
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P.O. Box 2003
New Brunswick, NJ 08903

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Plumbing Products Division
Mansfield, OH 44901

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Georgia -- 1534 Dunwoody Village
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Ohio -- 8040 Hosbrook Road, Suite
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Suite 177, Dallas TX 75247,
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"Two-Stage Flush Valve"
7500 Linder Avenue Box 1022
Skokie, IL 60077

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17900 Skypark Circle
Irvine, CA 92664

Elgin "Emblem" 3.5 Gallon Flush
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Pittsburgh, PA 15222
(412) 471-2402

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1.0 Gallon Flush
P.O. Box 1285
Ann Arbor, MI 48106

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1100 Boone Dr.
Michigan City, IN 46360

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495 Main Street, P.O. Box 1020
Murphys, CA 95247

International Water Saver Toilets Inc.
1.0 Gallon Flush
Box 416
Valley City, OH 44280

Kohler "Wellworth Water-Guard"
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Kohler, WI 53044

Micropher Air Assisted
Two Quart Flush Model LF-210-TE
P.O. Box 40
Willis, CA 94540
(707) 459-5563

Savway Co., Inc. 2 Stage Flush
930 Clarkson Ave.
Brooklyn, NY 11203

Universal-Rundle "Thermo-Tank"
3.5 Gallon Flush
217 North Mill Street
New Castle, PA 16103

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P.O. Box 552 401 West Main Street
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Ch, FE Div, AJEN-FE 96343
Fac Engr (Honshu) 96343
Fac Engr (Okinawa) 96331

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Arnold Air Force Station, TN 37389

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Vanderberg AFB, CA 93437

416th Engineer Command 60623
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US Military Academy 10996
ATTN: Facilities Engineer
ATTN: Dept of Geography & Computer Science
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Dugway Proving Ground 84022
Jefferson Proving Ground 47250
Fort Monmouth 07703
Letterkenny Army Depot 17201
Natick R&D Ctr. 01760
New Cumberland Army Depot 17070
Pueblo Army Depot 81001
Red River Army Depot 75501
Redstone Arsenal 35809
Rock Island Arsenal 61299
Savanna Army Depot 61074
Sharpe Army Depot 95331
Seneca Army Depot 14541
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Tooele Army Depot 84074
Watervliet Arsenal 12189
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Fort Bragg 28307
Fort Campbell 42223
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Fort Devens 01433
Fort Drum 13601
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